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# TENSILE AND HARDNESS TESTS ON POLYESTER FABRIC REINFORCED NEOPRENE RUBBER SEALS USED IN PICKERING NGS 'A' PRESSURE RELIEF DUCT EXPANSION/CONTRACTION JOINTS

Report No. 90-173-K

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## Abstract

Tensile test specimens were cut from sections of both spliced and non spliced polyester fabric reinforced neoprene rubber material which had been used as seals on the contraction joints of the Pickering NGS 'A' pressure relief duct. These specimens were tested for durometer hardness and then tensile tested to destruction. It was found that the specimens containing the splice had only 30% of the strength of the non splice specimens. Comparison was made with a similar specimen of polyester fabric reinforced silicone rubber material used for the replacement PRD contraction joint seals. It was found that the non splice neoprene seals were stronger than the silicone seals but since the silicone seals are specified to have 90% strength in the splice the silicone seal splices are considerably stronger than the neoprene seal splices. The silicone seal material also has nine times the elongation at break than the neoprene seal material.



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## EXECUTIVE SUMMARY

# TENSILE AND HARDNESS TESTS ON POLYESTER FABRIC REINFORCED NEOPRENE RUBBER SEALS USED IN PICKERING NGS 'A' PRESSURE RELIEF DUCT EXPANSION/CONTRACTION JOINTS

R.J. Lewak

Sections of both spliced and unspliced polyester fabric reinforced neoprene rubber contraction joint seal material which had been used in a contraction joint seal in Pickering NGS 'A' PRD were sent from Pickering NGS to Research Division for testing. Tensile test specimens were cut from the sections in a longitudinal direction so that half the specimens contained a splice and half contained unspliced material. Shore A durometer hardness tests were then taken on the specimens according to ASTM 2240. As the specimens had a level of radioactive contamination which could not be removed, the specimens were wrapped in polyethylene film to prevent any disbursement of contamination during tensile testing. The specimens were then tensile tested to destruction. It was found that the specimens without a splice had a failure of both fabric and rubber occur at the same strain of 35%. The splice specimens had a fabric failure at about 16% strain followed by delamination of the rubber and fracture of each rubber layer at separate strain values. The maximum stress for the splice specimens was only 30% of unspliced specimens. Comparison was made with tensile test results from a similar specimen of the replacement seal material of polyester fabric reinforced silicone rubber. The silicone specimen had 58% of the strength of the neoprene unspliced specimens. However, as the silicone seal has a specification of splice strength of 90% of unspliced material strength, the splice in the silicone seals will be considerably stronger than the splice in the old neoprene seals. The rubber elongation of the silicone seals is nine times greater than that of the neoprene rubber so that flexibility of the new seals will be higher than the old seals. It is concluded that the increase in splice strength and elongation and overall seal flexibility justifies the replacement



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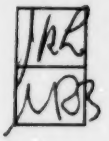
of the old polyester reinforced neoprene rubber Pickering NGS 'A' PRD contraction joint seals with ones of polyester rubber reinforced silicone rubber.



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To: Mr. R. Jeppesen
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**TENSILE AND HARDNESS TESTS ON POLYESTER FABRIC REINFORCED NEOPRENE RUBBER SEALS USED IN PICKERING NGS 'A' PRESSURE RELIEF DUCT EXPANSION/CONTRACTION JOINTS**

## 1.0 INTRODUCTION

Sections of the polyester fabric reinforced neoprene rubber pressure relief duct (PRD) expansion/contraction joint seal from a contraction joint of Pickering 'A' were sent from Pickering NGS to Research Division in Toronto for tests on the material for comparison with the polyester fabric reinforced silicone rubber seal material which had been used for replacement of the Pickering NGS PRD contraction joint seals in May 1990. These sections contained spliced material as well as unspliced material. Since this material had been installed in the PRD since the early 1970's it had, over the years, become contaminated by radioactive materials. Therefore the sections were first delivered to the Research Division Radioactive Materials Laboratory (RML) for decontamination. However, it proved difficult to remove all of the contamination without destroying the material so it was decided to cut tensile specimens in the RML, wrap them in polyethylene film so that contamination would not be disbursed and then test them for tensile strength.

## 2.0 TEST SPECIMENS AND PROCEDURE

The test specimens, four in total, all had the same nominal dimensions. All were dumbbell shaped with the wider ends having a width of 2.54 cm, the narrow test section having a width of 1.2 cm and the thickness of the specimen is a nominal 5 mm. The gauge length, that is, the length of the narrow test section, was nominally 16.7 cm.

Of the four specimens, two had been cut in the longitudinal direction of the seal so that the splice would be centered in the test section of the specimen. Two were cut from an unspliced section but in the longitudinal direction. A fifth specimen having the same dimensions as the above four was cut from the new seal material, polyester reinforced silicone rubber for comparison tests.

Before wrapping the Pickering 'A' test specimens in polyethylene film for transport out of the RML, durometer hardness tests were performed at various positions along the length of the specimens using a Shore A hardness tester according to ASTM 2240.

The specimens were then wrapped in the polyethylene film and tensile tested to destruction using a JJ INSTRUMENTS T5K tensile testing machine with self locking and aligning jaws. The elongation and force to produce this elongation was recorded. The elongation speed was 8 mm/min which is a strain rate of 5%/min.

## 3.0 TEST RESULTS

### 3.1 Durometer Hardness Tests

Specimen 1 and 2 contained the splice sections. The average Shore A hardness for the splice area on specimen 1 was 68 while the ends of specimen 1 had a hardness of 61. Specimen 2 had a splice area hardness of 71 while the ends had a hardness of 62. As for specimens 3 and 4 from the unspliced area, they uniformly had an average Shore A hardness of 62. The new seal specimen, specimen 5, had a uniform hardness of 64.

### 3.2 Tensile Test Results

The stress-strain curve for specimen 1 is shown in Figure 1. At a strain of 15% the maximum stress of 8.5 MPa is reached at which point all contribution to strength by the fabric is lost. The rubber continues to stretch at much lower stress levels until a strain of 32% at a stress of 6.3 MPa at which point the rubber delaminated into two layers and one layer fractured. The other layer took up the load until final fracture at 46.8% strain. A similar result is seen for specimen 2 in Figure 2 which reached a maximum stress of 11.6 MPa at a strain of 17% at which point the fabric fractured and the rubber remained to take the load up to 5.9 MPa at 24% at which point delamination occurred accompanied by fracture of one layer. The strain at fracture is 47% at a stress of 2.7 MPa. Fracture, of course, is accompanied by considerable necking of the specimen so that the measured stress is not the true stress. For the two spliced specimens the average maximum stress is 10 MPa at a strain of 16.3% and the maximum elongation is 47%.

The stress-strain curve for specimen 3 is shown is Figure 3. For this specimen the fracture of both rubber and fabric occurred at 36% strain at a stress of 35.6 MPa. A similar result is seen for specimen 4 in Figure 4 with fracture of both rubber and fabric at 33% strain at a stress of 31.5 MPa. The average ultimate tensile strength for the unspliced specimens is 33.35 MPa at a strain of 34.4%.

The stress-strain curve for specimen 5 is shown in Figure 5. The maximum stress is 19 MPa at a strain of 37% at which point the fabric breaks and all the load is taken by the cover silicone rubber. The specimen then elongates to a strain of 316% before fracture at a stress of 6 MPa.

## 4.0 DISCUSSION OF RESULTS

The durometer hardness values of the specimens were expected. That is, the splice areas have consistently shown a high Shore A hardness when compared to the rest of the seal. It was not known if this was due to high original hardness or if the splice area was materially different from the unspliced area and therefore aged differently. The high hardness levels of the splices in the Pickering NGS 'A' PRD seals was one of the reasons given for seal replacement as the flexibility of the splice areas of these seals could not be guaranteed over the time period between station outages.

The splice areas show a strength of only 30% of the seal strength. However, it must be mentioned that the polyester/neoprene seal strength is extremely high at over 30 MPa. The new polyester/silicone seal strength is 58% of the old polyester/neoprene. However, the specified splice strength of the new seal is 90% of the unspliced material. Therefore, the new seal splices will have 171% more strength than the old Pickering 'A' contraction joint seal splices. Furthermore, the elongation of the new seal is nine times greater than that of the old seals showing the large flexibility present in the new seals when compared to the old.

## 5.0 CONCLUSIONS

The new polyester reinforced silicone rubber contraction joint seal material is considered superior to the old seal material of polyester reinforced neoprene rubber on the basis of splice strength and elongation and total flexibility. Aside from the splices, however, the old polyester reinforced neoprene material shows considerable strength due to the high strength of the fabric. The neoprene cover rubber, however, exhibits only one tenth the elongation of the silicone cover rubber of the new seals so the replacement of the old material with the new is justified.

## 6.0 ACKNOWLEDGEMENT

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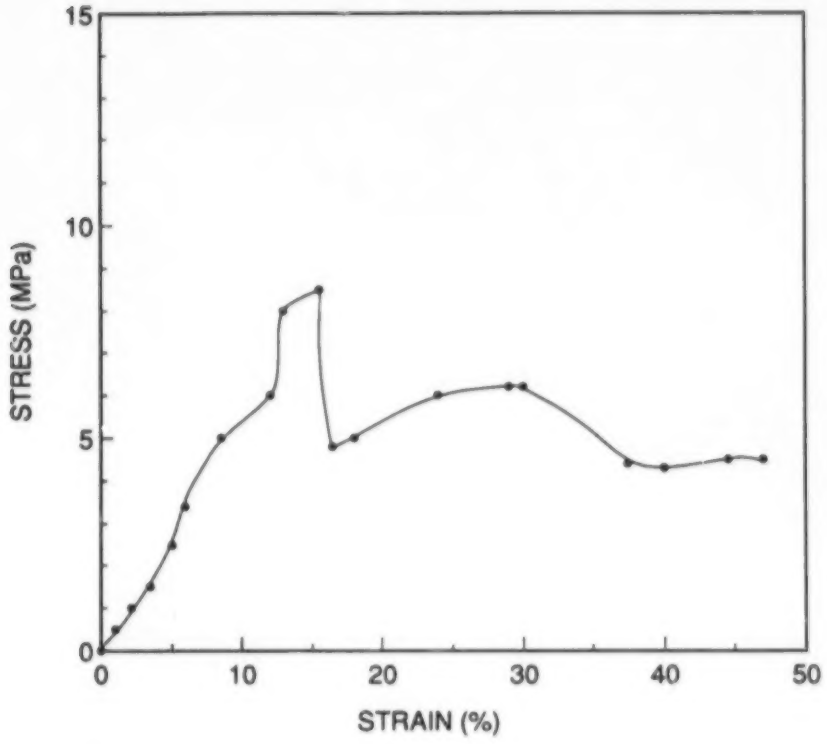


Figure 1 Stress-Strain Curve for Specimen 1
Pickering NGS 'A' PRD Seal Splice
Section

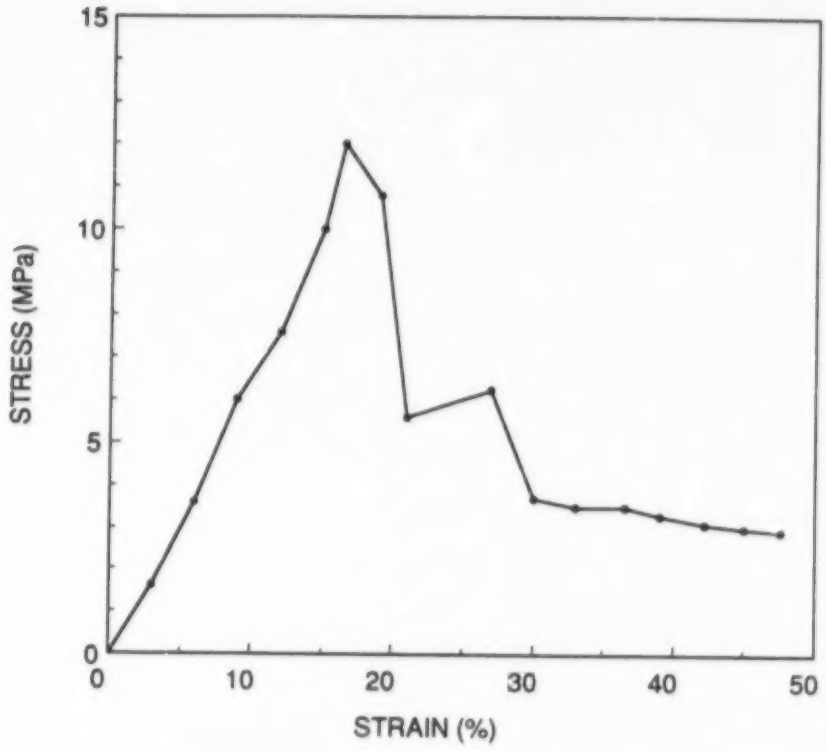


Figure 2 Stress-Strain Curve for Specimen 2 Pickering NGS 'A' PRD Seal Splice Section

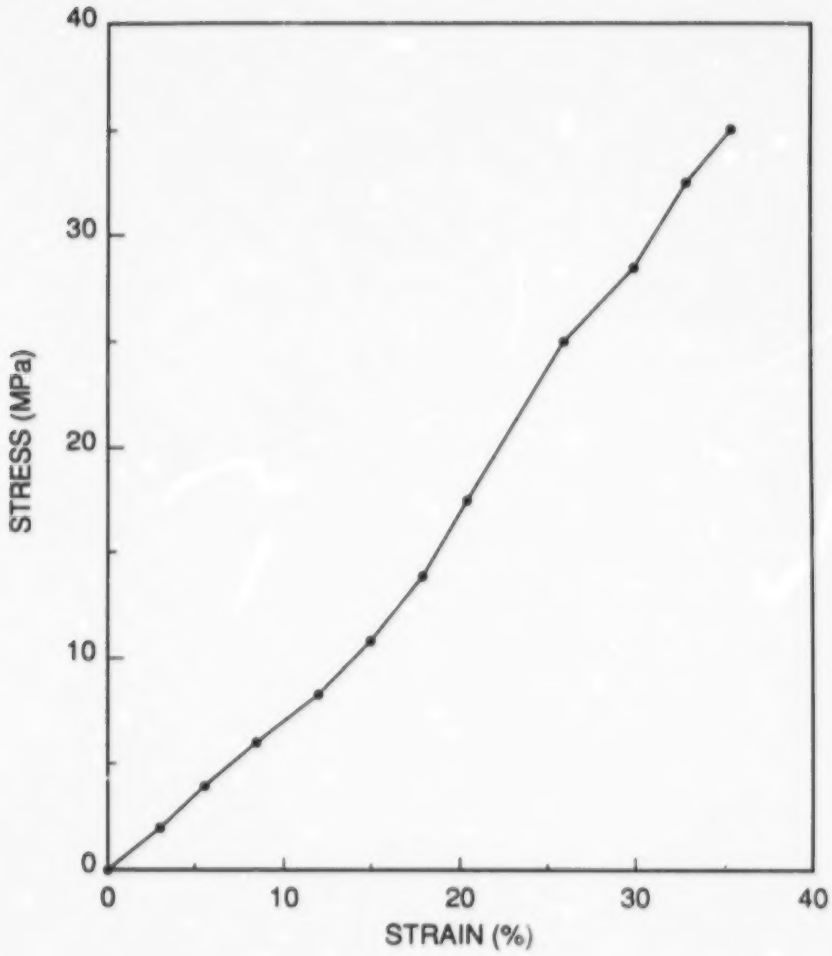


Figure 3 Stress-Strain Curve for Specimen 3
Pickering NGS 'A' PRD Seal
Unspliced Section

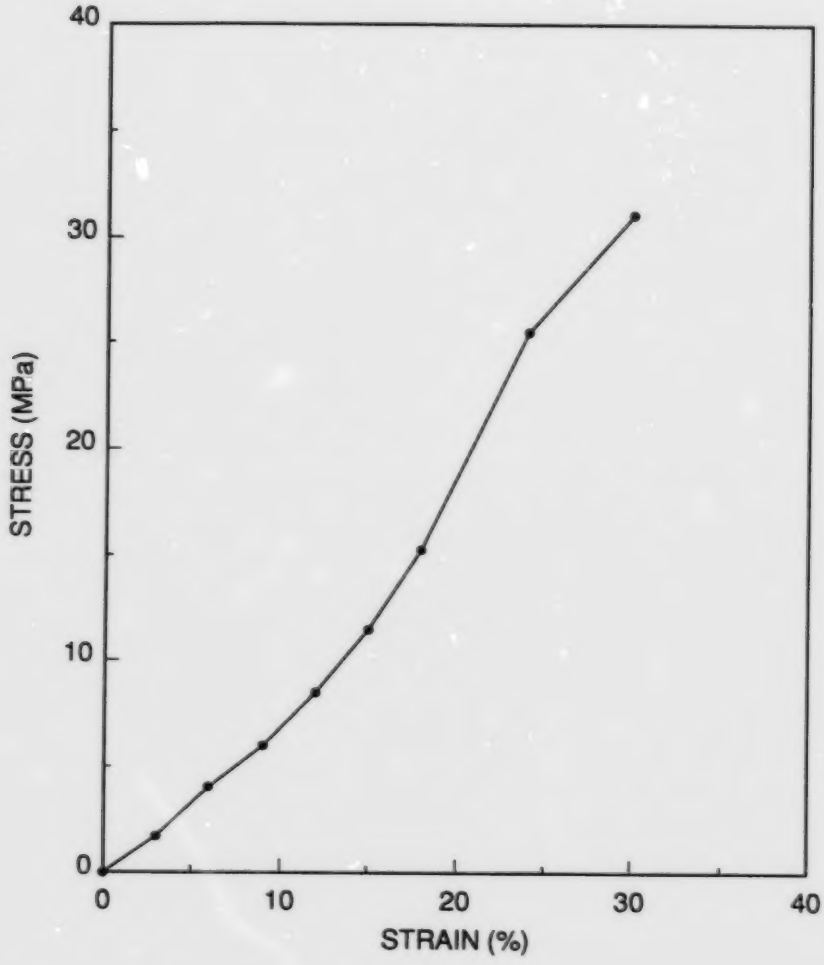


Figure 4 Stress-Strain Curve for Specimen 4
Pickering NGS 'A' PRD Seal Unspliced
Section

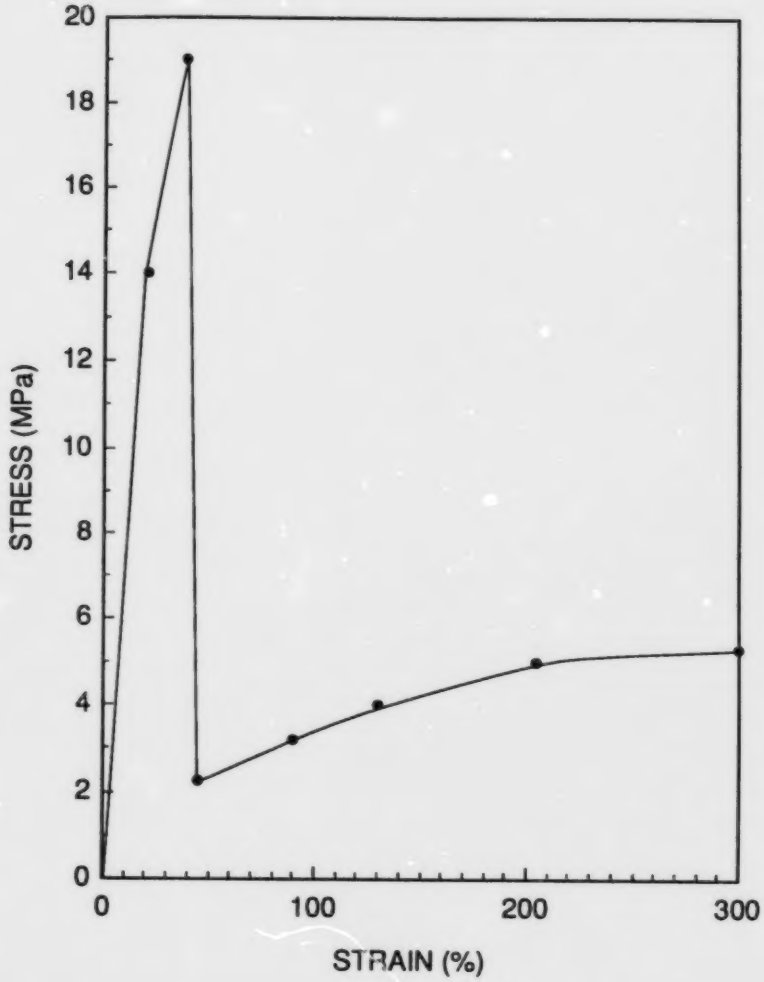


Figure 5 Stress-Strain Curve for Specimen 5
Replacement PRD Seal Material
Polyester Reinforced Silicone Rubber